T A B L E & F I G U R E

Table II-1 GEOLOGIC COMPOSITIONS DISTRIBUTED IN THE PROPOSED AREA

Age				Geologic Name	Composition	Remarks
Cenozoic	Quaternary			Alluvium	Gravel, Sand, Silt, Clay and Peat	Distributed around the proposed damsites'area
Cenozoic	Tertiary	Neogene	Miocene	Tanjong Formation	Mudstone, Shale, Siltstone with Some Sandstone and Rare Limestone, Conglomerate, including Coal	"
Cenozoic	Tertiary	Neogene	Miocene	Kuamut "	Mudstone, Shale, Sandstone Conglomerate and Slump Breccia	"
Cenozoic	Tertiary	Palaeogene	Palaeocene, Oligocene Eocene	Labang "	Sandstone, Mudstone, Shale and Less Limestone	"
Cenozoic	Tertiary	Palaeogene	Palaeocene, Oligocene Eocene	Kulapis "	Predominant Red Sandstone and Shale	Distributed within 30 km from the proposed dam-sites'area
Cenozoic	Tertiary	Palaeogene	Palaeocene, Oligocene Eocene	Crocker "	Sandstone, Shale, Mudstone and their alternations	"
Cenozoic	Tertiary	Palaeogene	Palaeocene, Oligocene Eocene	Sapulut "	Mudstone with Some Sandstone Conglomerate and Limestone	"
Mesozoic	Creta-ceous			Chert-Spilite "	Chert, Spilite, Sandstone and Limestone	"
Igneous rocks and Crystalline Basement rocks				Ultramafic, Mafic rocks and Metamorphic rocks	Gabbro, Diorite, Dolerite, Grano-diorite, Peridotite, Serpentine, Amphibolite, Gneiss and Schist	"

Table II-2 SUMMARY OF BOREHOLE NO.1

	Depth from Ground Surface (m)	Type of Soil or Rock	Description	No. of Blows of S.P.T.	Symbol divided by U.S.C.S.	Natural Moisture Content (%)
River Deposit	0 - 15.4	Clay	Dark brown silty clay with sand lenses and decayed wood fragments.	N = 4 (0 m - 5.5 m in depth) N = 6 - 10 (5.5 m - 11.5 m in depth) N = 10 - 17 (11.5 m - 15.5 m in depth)	CL	12.6 - 35.7
	15.4 - 16.8	Sand	Clayey sand	N = 13	SC	(16.9)
	16.8 - 18.1	Clay	Silty clay.	N = 12	CL	(12.6?)
	18.1 - 24.5	Sand	Five to medium sand with thin clay layer.	N = 19 - 22	SC	16.2 - 21.6
	24.5 - 26.9	Clay (loose sand?)	No core is obtained. Clayey soils are inferred by No. of blows of S.P.T. or loose sand.	N = 3 - 4	-	-
	26.9 - 35.0	Sand and gravel	Medium to coarse sand and gravels.	N = 33 - 43	SW, SP SW-SC	-

Note: This hole was at first expected to be drilled down to 50 m in depth, but stopped by 35 m in depth due to the encounter of three jammings during the drilling operation.

Table II-3 SUMMARY OF BOREHOLE NO.2

Depth from Ground Surface (m)	Type of Soil or Rock	Description	No. of Blows of S.P.T.	Symbol divided by U.S.C.S.	Natural Moisture Content (%)
0 - 2.5	Clay	Yellowish brown clay.	N = 5 - 10 (0 m - 2.5 m in depth)	CL	18.0 - 28.7
2.5 - 4.9	Clay (Weathered Soil)	Medium stiff to stiff yellowish brown mottled silty clay with some fragments of sandstone.	N = 15 - 22 (2.5 - 4.9 m in depth)	CL	26.2
4.9 - 6.9	Shale	Grey shale. Brecciated core is obtained.	N = 27 - 31	-	-
4.9 - 8.2	Sand-stone	Grey fine sandstone. Hard.	-	-	-
8.2 -30.0	Shale	Dark grey in color. Many cracks are found and brecciated core is obtained. Some of cracks have sheared traces on their surfaces.	-	-	-

Note: Three Lugeon tests (water pressure tests) were carried out. 0.7 Lugeon was obtained by the test betwee 23.0 m and 28.1 m in depth, but the other two tests were failed.

Water level was measured by 5.38 m from ground surface.

Table II-4 SUMMARY OF BOREHOLE NO.3

Depth from Ground Surface (m)	Type of Soil or Rock	Description	No. of Blows of S.P.T.	Symbol divided by U.S.C.S.	Natural Moisture Content (%)
0 - 4.4	Clay (Weathered Soil)	Soft to medium stiff yellowish brown to grey mottled silty clay with some fragments of weathered sandstone.	N = 8 - 12	CL, CH	14.6 - 33.6
4.4 - 5.0	Sand (Weathered Soil)	Fire to medium grained weathered sandstone. Light grey to yellowish grey in color.	N = 22	-	-
5.0 -12.9	Clay (Weathered Soil)	Highly weathered soil. Stiff to very stiff grey silty clay with weathered sandstone fragements.	N = 15 - 25	CL CL-ML	11.4 - 29.1
12.9 -20.0	Shale	Shale and sheared soft mudstone slicker side is found. Light grey in color.	-	-	-

Note: Lugeon test (water pressure test) was carried out between 15.3 m and 20.4 m in depth, but failed because of serious leakage.

No water level in the borehole was measured.

Table II-5 SUMMARY BOREHOLE NO.4

Depth from Ground Surface (m)	Type of Soil or Rock	Description	No. of Blows of S.P.T.	Symbol divided by U.S.C.S.	Natural Moisture Content (%)
0 - 4.0	Clay	Soft yellowish brown mottled silty clay.	N = 3 - 5	CH	12.7 - 49.2
4.0 - 5.0	Clayey Sand	Completely weathered sandstone. Yellowish brown to brownish orange.	N = 5	-	-
5.0 - 6.4	Shale	Grey to dark grey weathered shale. Some show weathered soil.	N = 38 - 50	ML	14.2
6.4 - 9.32	Sand-stone	Fine to medium grained sandstone. Grey in color. Slightly weathered.	-	-	-
9.32 -10.0	Shale	Grey in color. Brecciated core is obtained.	-	-	-
10.0 -10.3	Sand-stone	Grey colored fine sandstone.	-	-	-
10.3 -10.9	Shale	Grey in color. Brecciated core is obtained.	-	-	-
10.9 -13.7	Sand-stone	Fine grained sandstone. Grey in color. Slightly weathered.	-	-	-
13.7 -30.0	Shale	Grey to pale brown in color. Sheared and brecciated zone is often found. This sandstone layer is interbedded.	-	-	-
30.0 -30.5	Sand-stone	Grey in color. Fine to medium grained sandstone with carbonaceous partings.	-	-	-
30.5 -40.0	Shale	Grey in color. Sheared and brecciated zone is often found. Thin sandstone layer is interbedded.	-	-	-

Note: Lugeon test (water pressure test) was carried out between 15.9 m and 20.5 m in depth, and 2.0 Lu was obtained below the pressure less than 5 kg/cm^2. Water level was measured by 1.19 m from ground surface.

Table II-6 SUMMARY OF BOREHOLE NO.5

Depth from Ground Surface (m)	Type of Soil or Rock	Description	No. of Blows of S.P.T.	Symbol divided by U.S.C.S.	Natural Moisture Content (%)
0 - 5.7	Clay	Very soft clay with some fragments of weathered sandstone and roots. Brownish orange to brownish grey in color.	N = 0 - 5	CL ML	30.7 - 37.9
5.7 - 9.9	Shale (Weathered Soil)	Brecciated core and clay are obtained. Grey to bluish grey in color.	N = 20 - 45	CL	10.1 - 13.9
9.9 -20.0	Shale	Brecciated core is obtained. Grey in color. Sheared zone is found in some parts.	-	-	-

Note: Lugeon test (water pressure test) was carried out between 16.6 m and 20.1 m in depth, but failed because of serious leakage.

Water level was measured by 1.87 m from ground surface.

Table II-7(1) RESULT OF SOIL TEST

(1)

No. of Sample		B-1	B-1	B-1	B-1	B-1	B-1	B-1	B-1	B-1	B-1
Sampling Depth (m)		1.0-1.45	2.0-2.45	3.0-3.45	4.95-5.41	6.93-7.39	8.90-9.37	9.90-10.36	10.90-11.35	11.90-12.34	12.90-13.34
Grain Size	Gravel content (%)	0.5	-	-	-	0.8	-	-	-	-	-
	Sand content (%)	36.3	14.1	9.3	1.1	1.7	7.0	5.9	22.0	3.2	3.2
	Silt content (%) / Clay content (%)	63.2	85.9	90.7	98.9	87.5	93.0	94.1	78.0	96.8	96.8
Consistency	Liquid limit (%)	29.2	37.0	30.5	33.5	34.2	27.7	39.0		37.5	29.0
	Plastic limit (%)	16.2	20.4	14.4	18.6	14.4	16.4	21.6		18.5	17.8
	Plasticity index	13.0	16.6	16.1	14.5	19.8	11.3	17.3		19.0	11.2
Unified soil classification		CL	CL	CL	CL	CL	CL	CL		CL	CL
Natural Moisture content (%)		18.4	16.0	28.3	28.9	26.5	22.3	23.3	26.6	35.7	32.8

(2)

No. of Sample		B-1	B-1	B-1	B-1	B-1	B-1	B-1	B-1	B-1	B-1
Sampling Depth (m)		14.85-15.31	15.85-16.30	16.85-17.30	18.10-18.45	19.81-18.40	21.80-22.25	23.45-23.90	28.42-28.87	29.40-28.97	30.4-30.86
Grain Size	Gravel content (%)	-	0.5	0.5	6.0	-	-	-	56.0	48.0	54.0
	Sand content (%)	10.7	51.0	6.9	58.0	86.7	59.4	82.9	41.3	50.2	43.3
	Silt content (%) / Clay content (%)	89.3	48.5	92.6	36.0	13.3	40.6	17.1	2.7	1.8	2.7
Consistency	Liquid limit (%)	25.3	27.0	37.2			27.5				
	Plastic limit (%)	17.9	15.4	22.8			12.6				
	Plasticity index	7.4	11.6	13.4			14.9				
Unified Moisture content		CL	SC	CL	(SC)	(SC)	SC	(SC)	SW	SW	SW
Natural Moisture content (%)		23.6	16.9	12.6	16.2	20.5	20.3	21.6			

Table II-7(2) RESULT OF SOIL TEST

(3)

No. of Sample		B-1	B-1	B-1	B-1	B-2	B-2	B-2	B-3	B-3	B-3
Sampling Depth (m)		31.47-31.84	32.38-32.84	33.37-33.84	34.36 34.82	1.00-1.45	2.00-2.45	4.95-5.40	1.00-1.45	2.00-2.45	3.00-3.45
Grain Size	Gravel content (%)	73.0	70.0	44.0	37.0	10.0	2.5	1.0	5.0	5.0	11.0
	Sand content (%)	26.1	29.1	50.2	56.1	5.5	10.4	3.2	1.9	13.5	6.0
	Silt content (%) / Clay content (%)	0.9	0.9	5.8	6.9	84.5	87.1	95.8	93.1	81.5	83.0
Consist-ency	Liquid limit (%)					43.5	42.4	40.7	53.0	44.5	48.0
	Plastic limit (%)					13.7	13.2	13.8	25.3	22.6	19.9
	Plasticity index					29.8	29.2	26.9	27.7	21.9	28.1
Unified soil classification		SP	SP	(SW-SC)	(SW-SC)	CL	CL	CL	CH	CL	CL
Natural Moisture content (%)						28.7	18.0	26.2	33.6	17.8	14.6

(4)

No. of Sample		B-3	B-3	B-3	B-3	B-3	B-3	B-4	B-4	B-4	B-4
Sampling Depth (m)		5.95-6.40	6.95-7.40	7.95-8.38	8.95-9.37	10.9-11.35	12.0-12.42	1.00-1.45	2.00-2.45	3.00-3.45	5.90-6.34
Grain Size	Gravel content (%)	0.5	36.0	4.0	9.0	15.0	5.0		1.0	1.0	0.5
	Sand content (%)	2.7	29.8	11.4	17.9	5.1	6.8		3.3	0.9	2.0
	Silt content (%) / Clay content (%)	96.8	54.2	84.6	73.1	79.9	88.2		95.7	98.1	97.5
Consist-ency	Liquid limit (%)	47.7	38.4	40.0	40.0	38.0	23.7	53.8	45.3		43.6
	Plastic limit (%)	23.2	18.2	18.7	22.3	26.5	19.0	20.4	20.2		27.8
	Plasticity index	24.5	20.2	21.3	17.7	11.5	4.7	33.4	25.1		15.8
Unified Moisture content		CL	CL	CL	CL	CL-ML	CL-ML	CH	CL		ML
Natural Moisture content (%)		14.2	14.3	16.5		11.4	29.1	43.1	49.2	12.7	14.2

Table II-7(3) RESULT OF SOIL TEST

(5)

No. of Sample		B-5	B-5	B-5	B-5	B-5	B-5	B-5
Sampling Depth (m)		1.00-1.45	2.00-2.45	3.00-3.45	3.95-4.41	4.95-5.41	5.95-6.40	8.91-9.37
Grain Size	Gravel content (%)	0.5	-	1.0	3.0	1.0	8.0	2.0
	Sand content (%)	0.8	0.4	1.3	1.1	2.5	4.5	2.4
	Silt content (%) / Clay content (%)	98.7	99.6	97.7	95.9	96.5	87.3	95.6
Consistency	Liquid limit (%)	43.0	48.0	35.7	34.0	36.7	37.0	40.8
	Plastic limit (%)	19.0	20.6	24.9	15.5	19.4	18.5	15.0
	Plasticity index	24.0	27.4	10.8	18.5	17.3	18.5	25.8
Unified soil classification		CL	CL	ML	CL	CL	CL	CL
Natural Moisture content (%)			34.3	37.9	34.5	31.5	13.9	10.1

Fig II-1(2)
PHYSIOGRAPHIC SUB-REGIONS

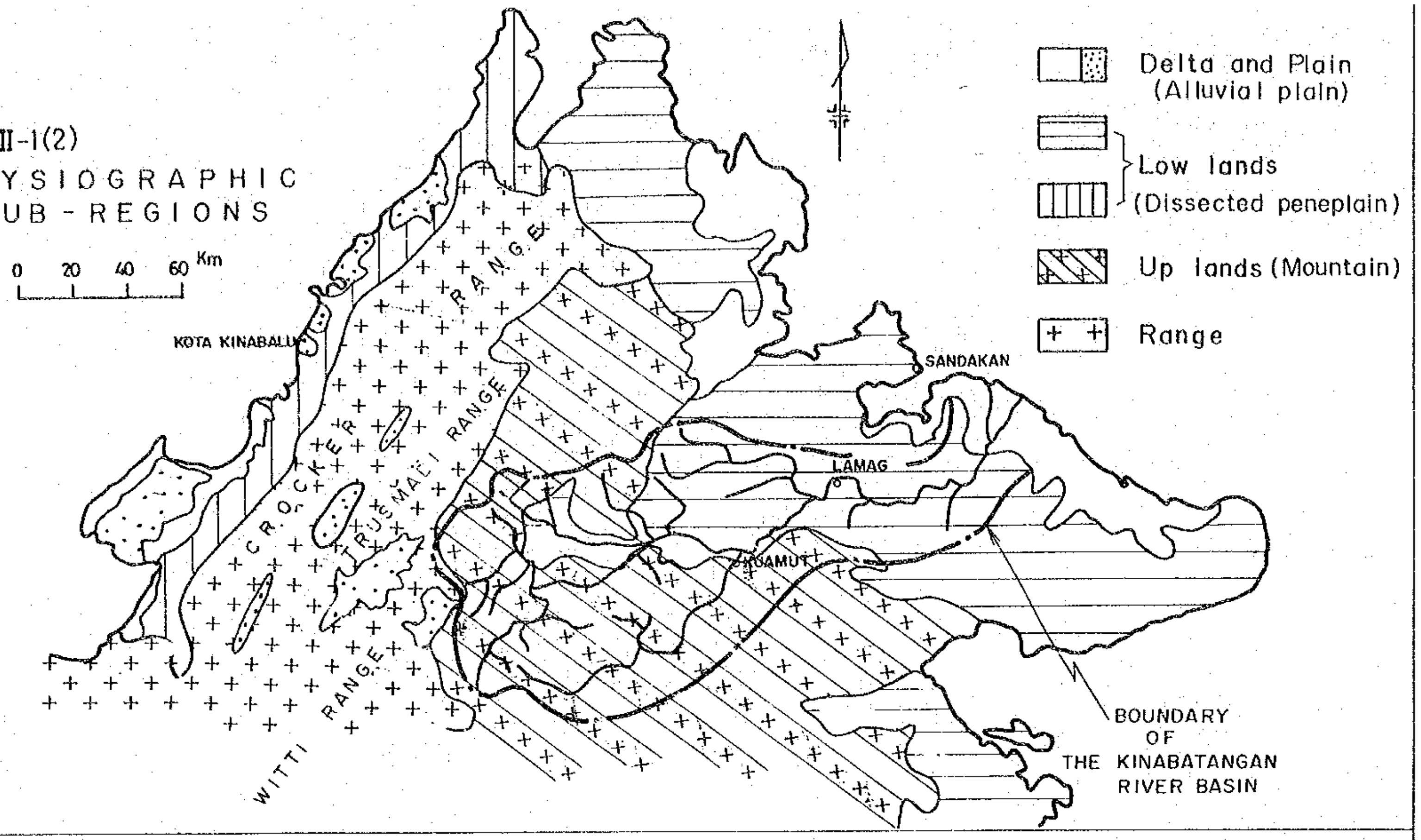


Fig. II-1(3)
GEOLOGIC MAP OF SABAH

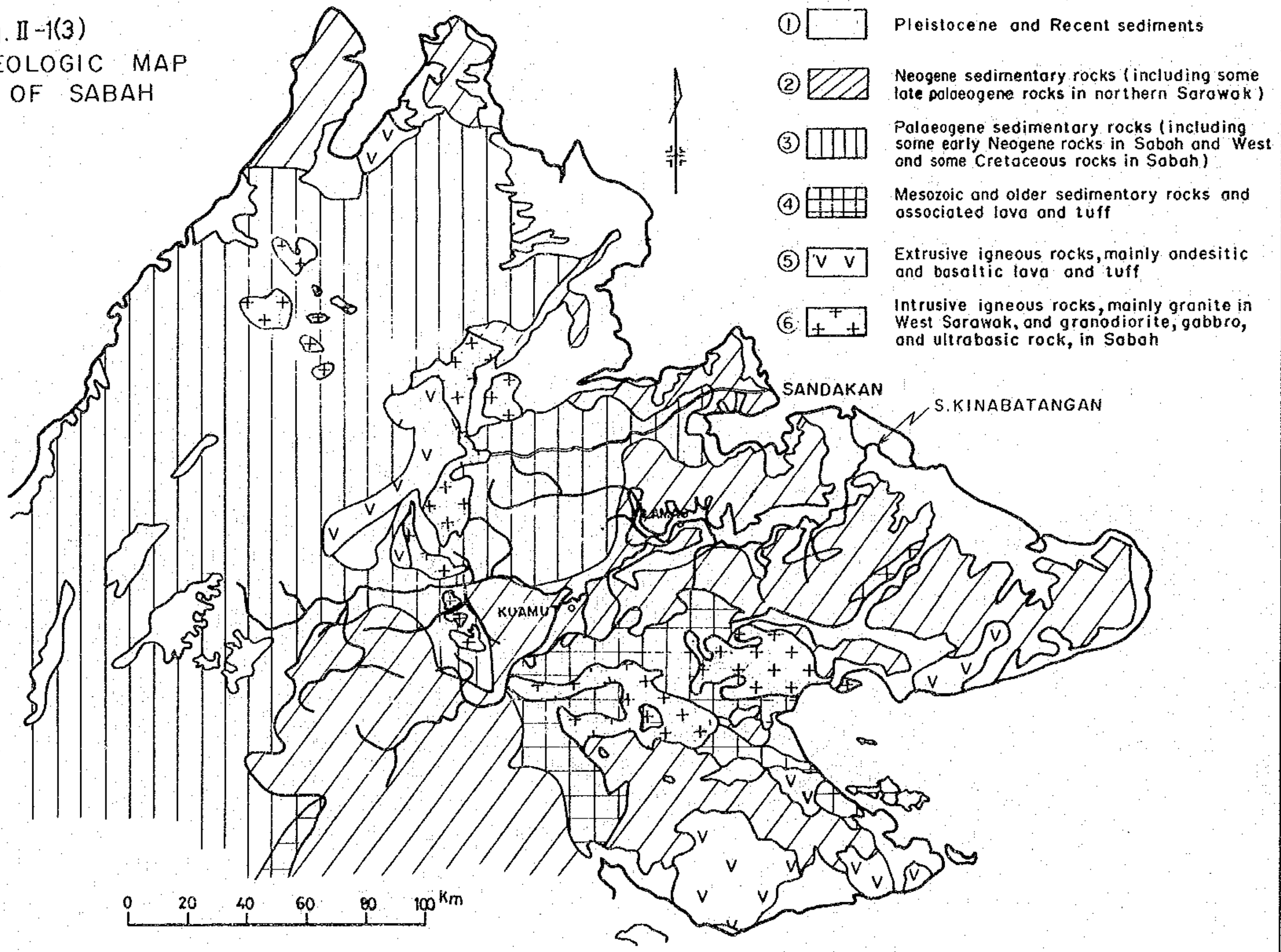
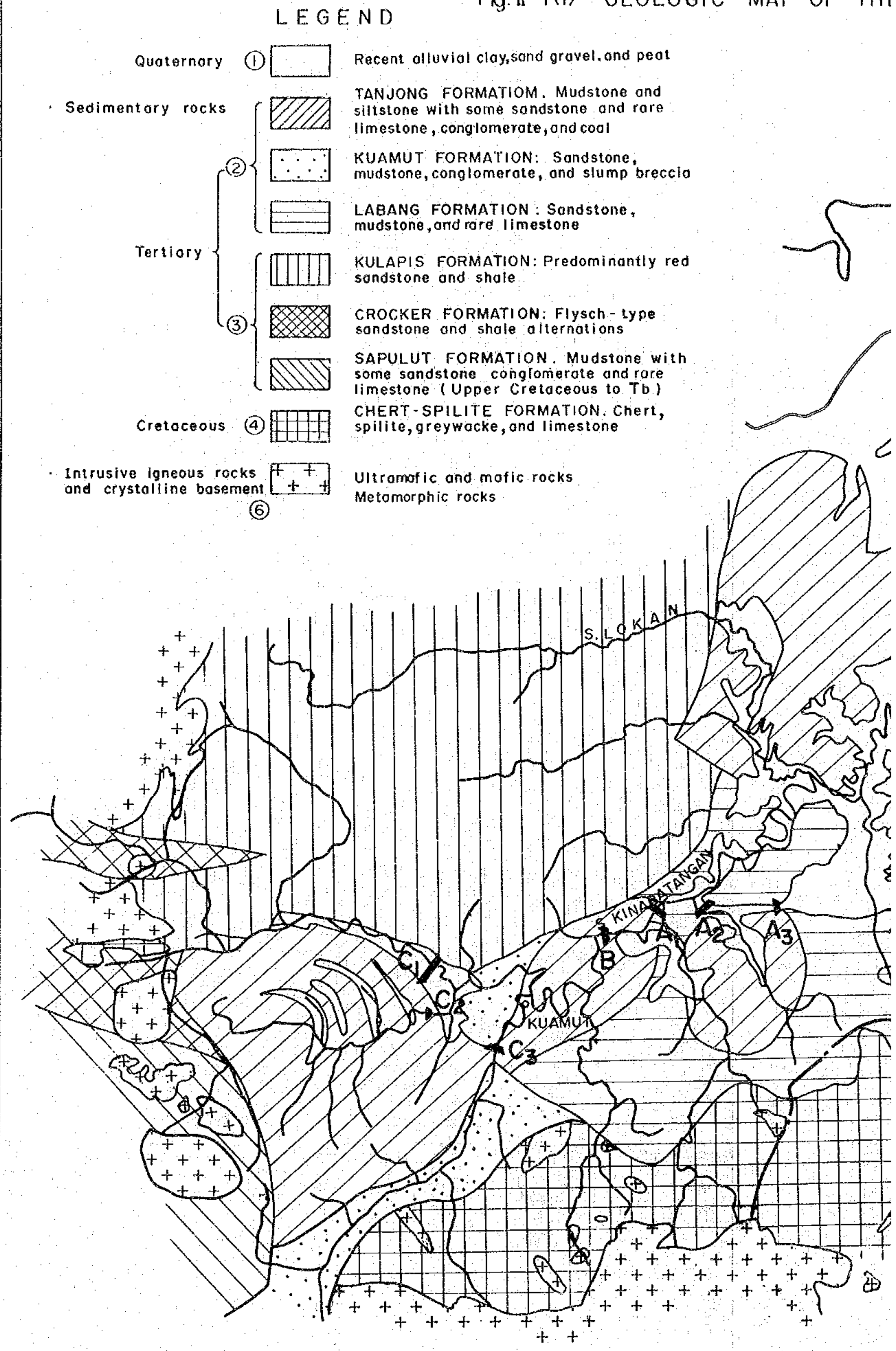
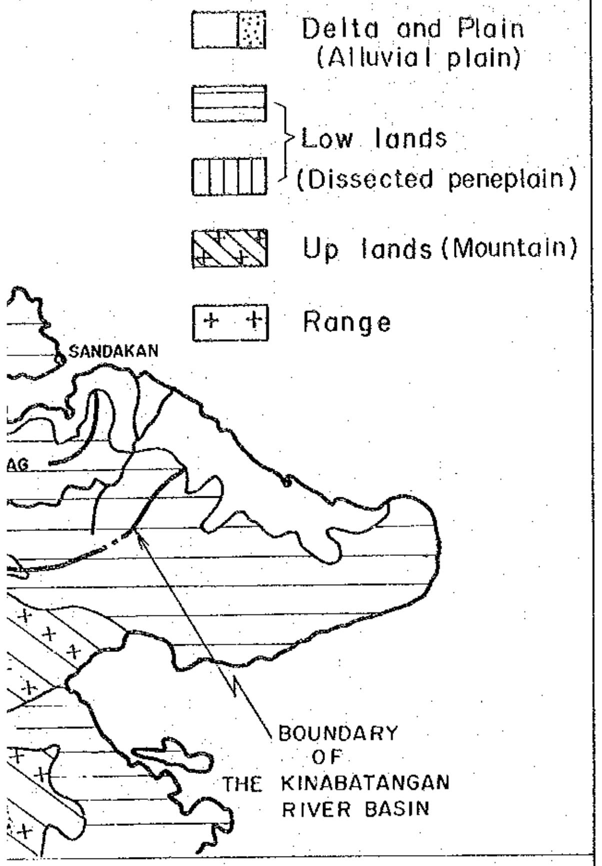


Fig.II-1 GEOLOGIC MAP

Fig. II-1(1) GEOLOGIC MAP OF THE





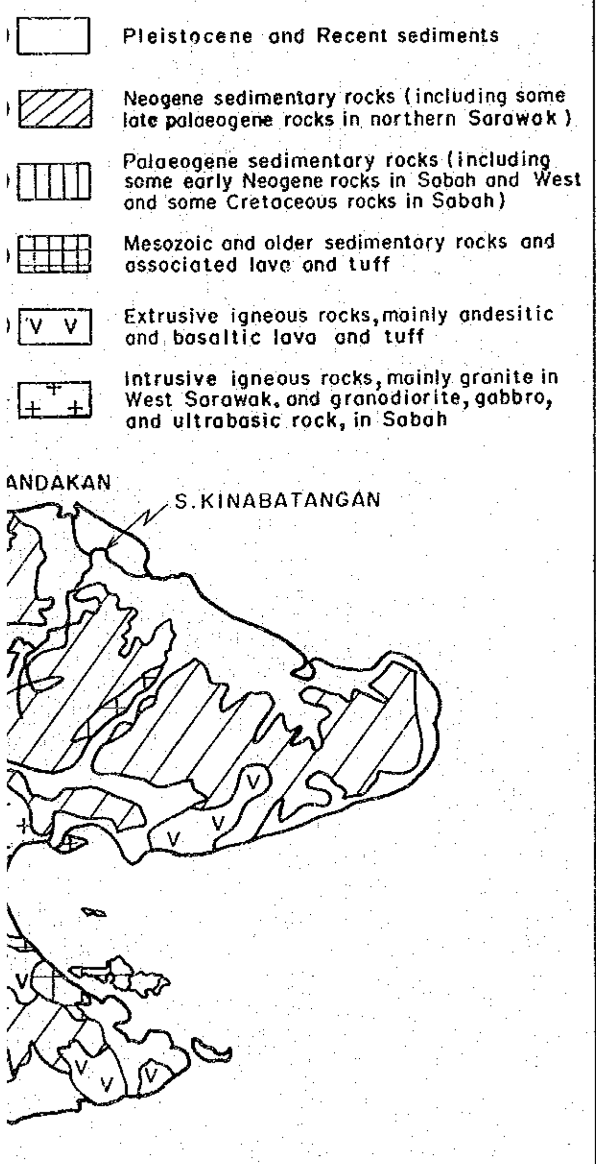


Fig.II-1 GEOLOGIC MAP AND PHYSIOGRAPHIC MAP

Fig.II-1(1) GEOLOGIC MAP OF THE PROPOSED AREA

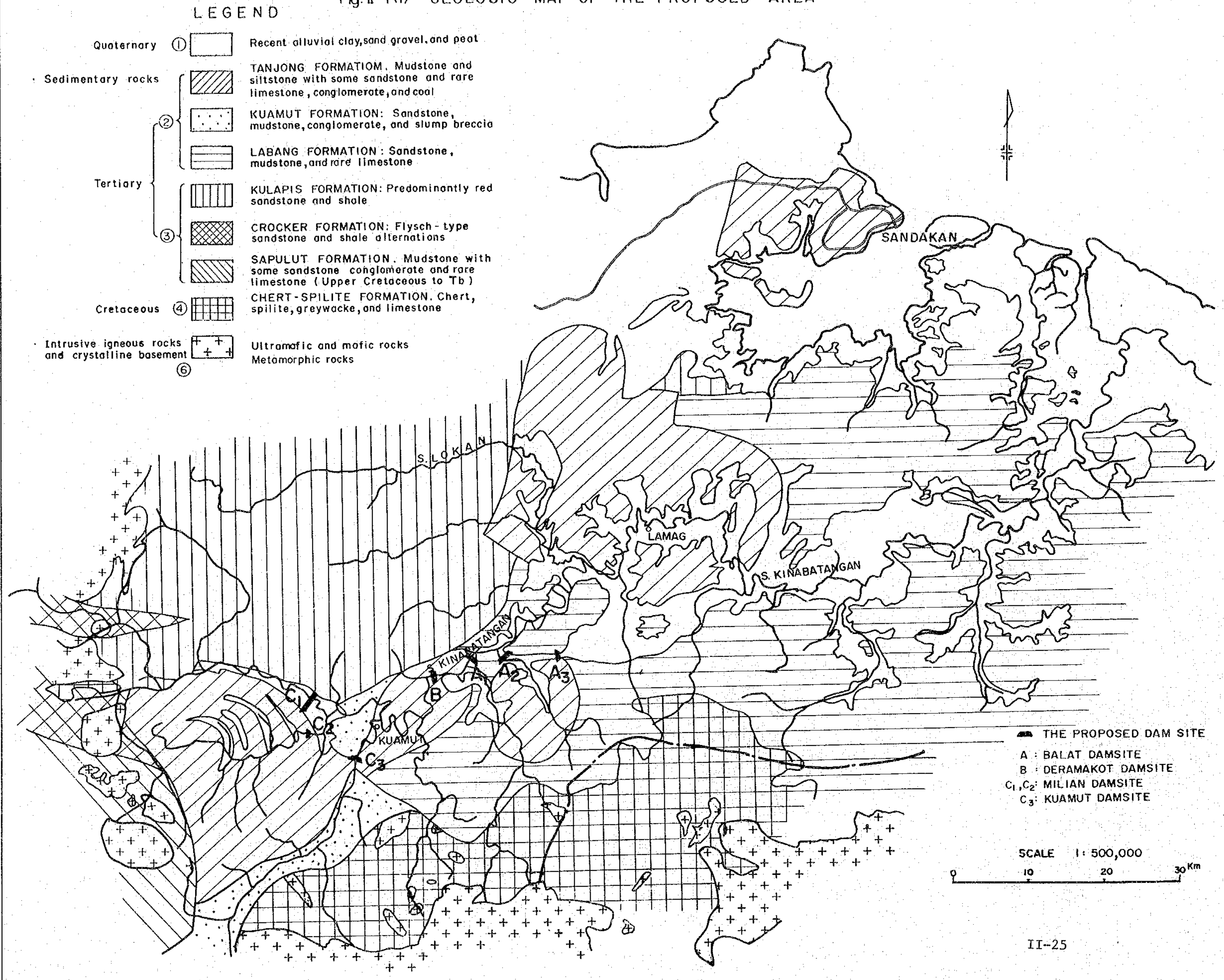
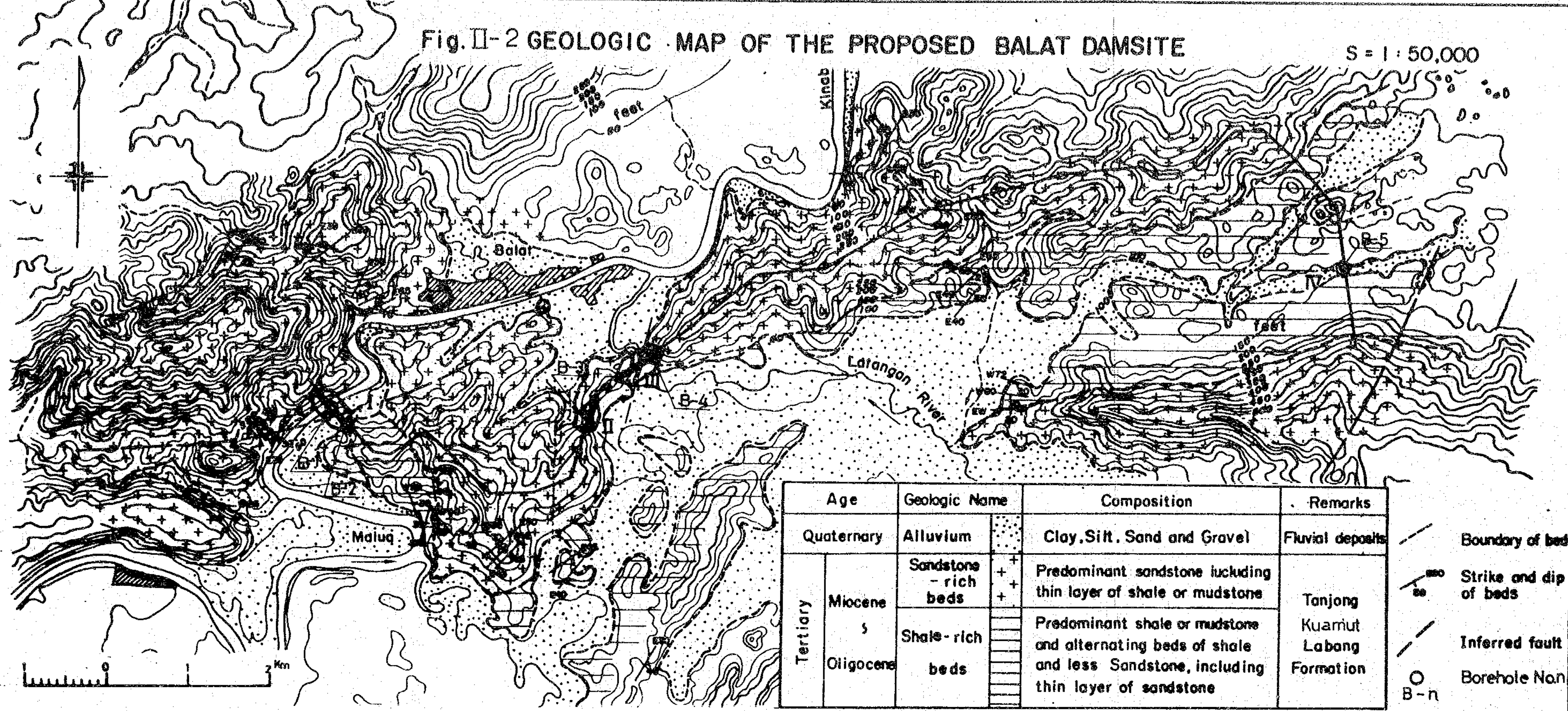


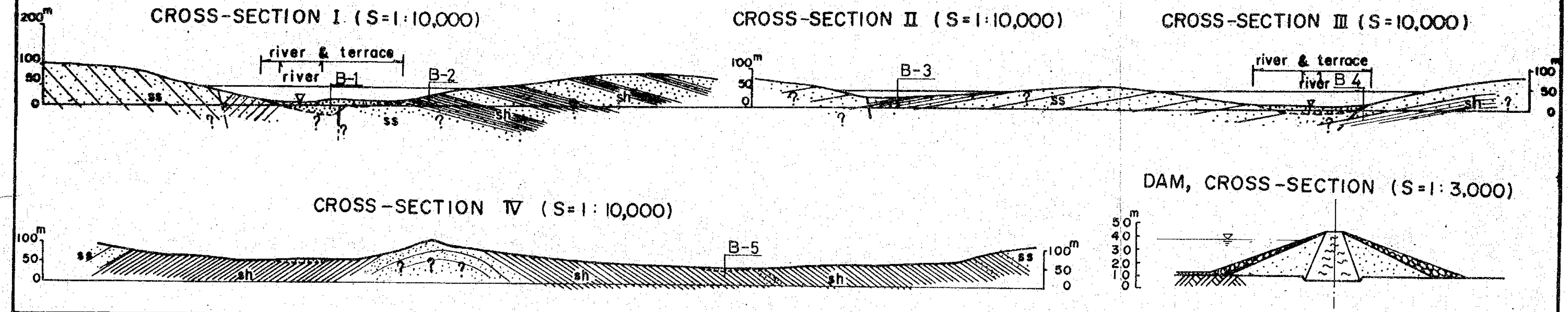
Fig. II-2 GEOLOGIC MAP OF THE PROPOSED BALAT DAMSITE



Age		Geologic Name		Composition	Remarks
Quaternary		Alluvium		Clay, Silt, Sand and Gravel	Fluvial deposits
Tertiary	Miocene ~ Oligocene	Sandstone - rich beds	+	Predominant sandstone including thin layer of shale or mudstone	Tanjong Kuamut Labang Formation
		Shale - rich beds		Predominant shale or mudstone and alternating beds of shale and less Sandstone, including thin layer of sandstone	

Note: Small outcrop of gabbro is reported to be found.

Note : Unclear boundaries of shale-rich beds around the main proposed damsite are written



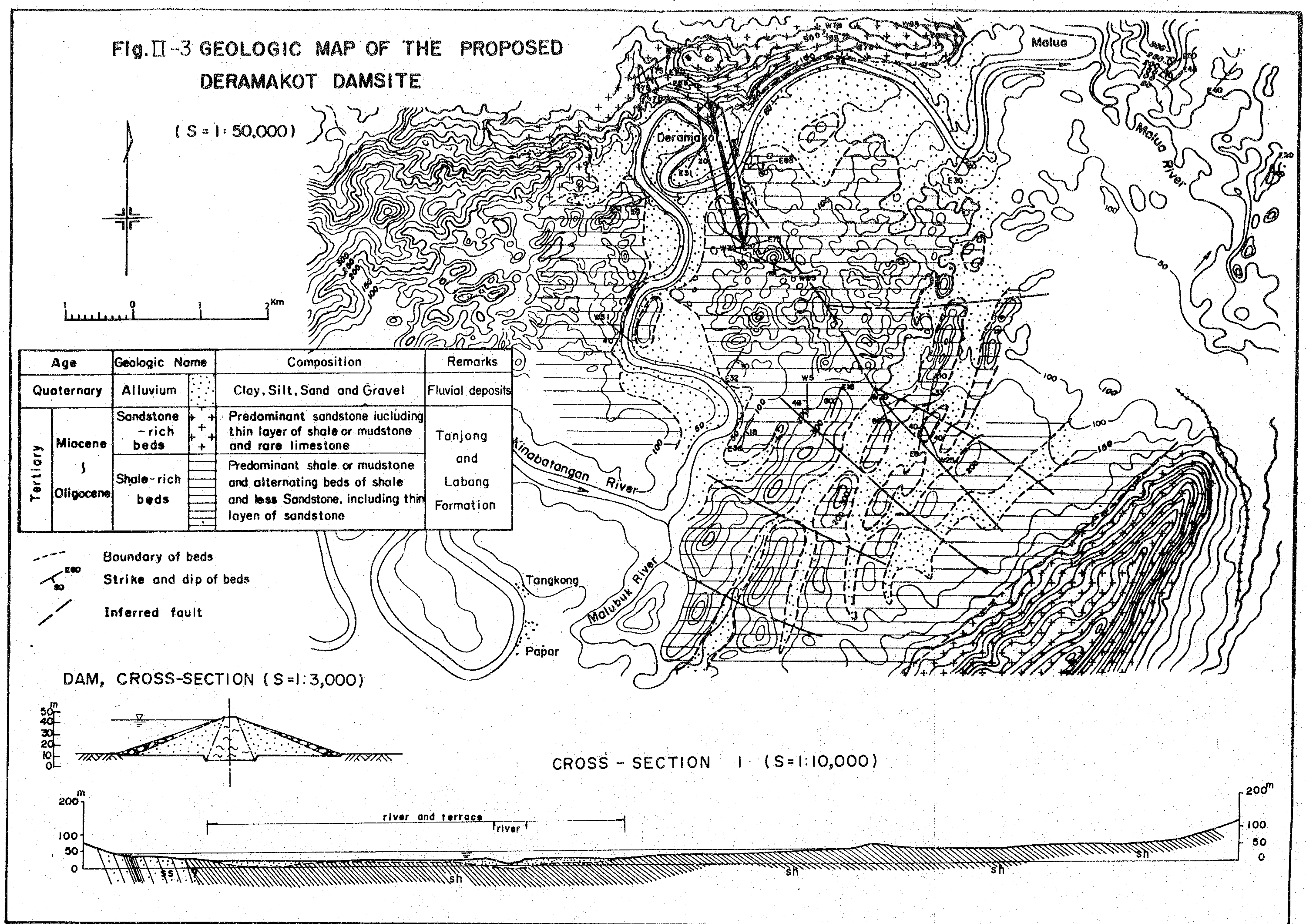


Fig.II-3 GEOLOGIC MAP OF THE PROPOSED DERAMAKOT DAMSITE

Age		Geologic Name	Composition	Remarks
Quaternary		Alluvium	Clay, Silt, Sand and Gravel	Fluvial deposits
Tertiary	Miocene ∫ Oligocene	Sandstone -rich beds	Predominant sandstone iucluding thin layer of shale or mudstone and rare limestone	Tanjong and Labang Formation
		Shale-rich beds	Predominant shale or mudstone and alternating beds of shale and less Sandstone, including thin layen of sandstone	

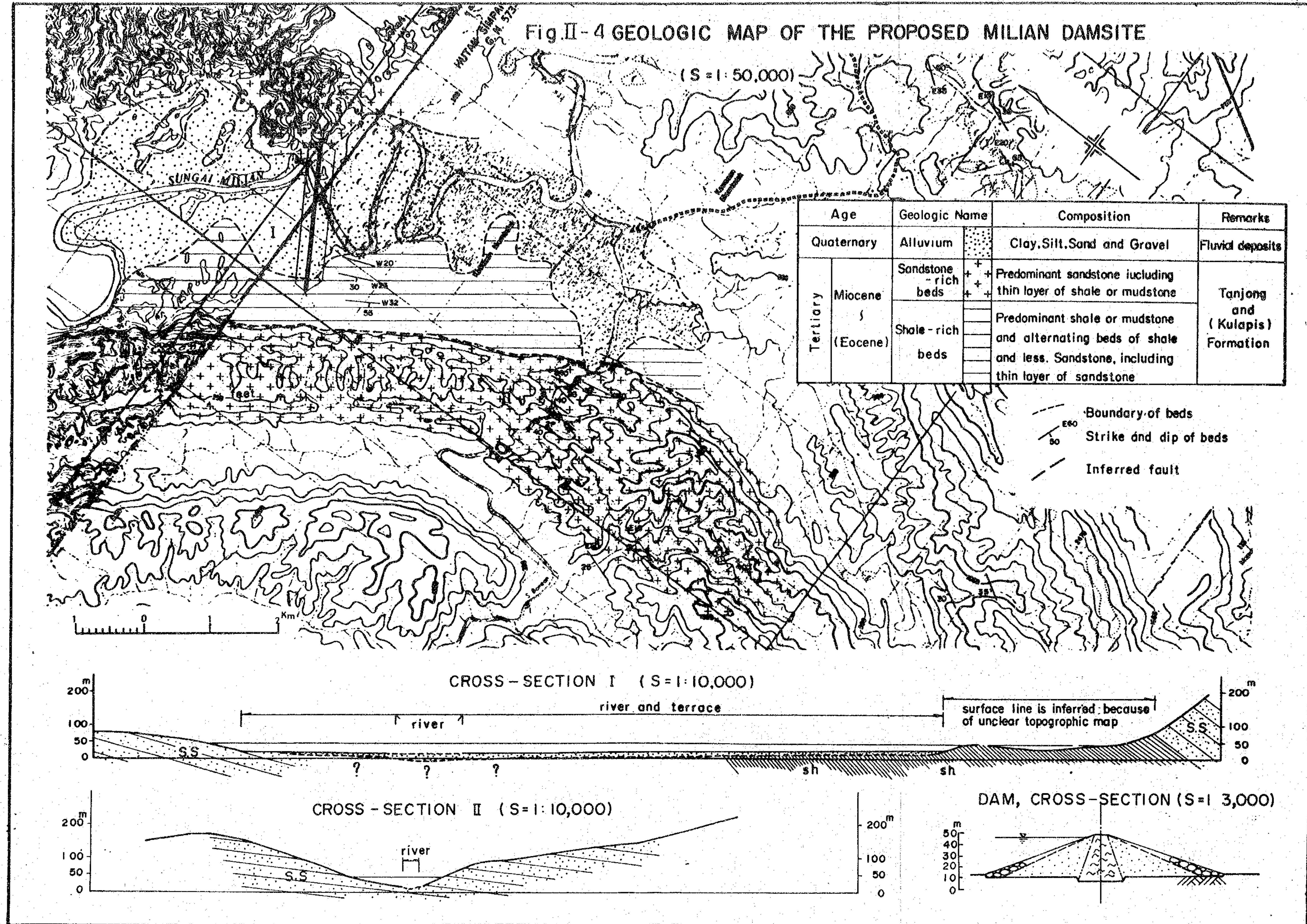
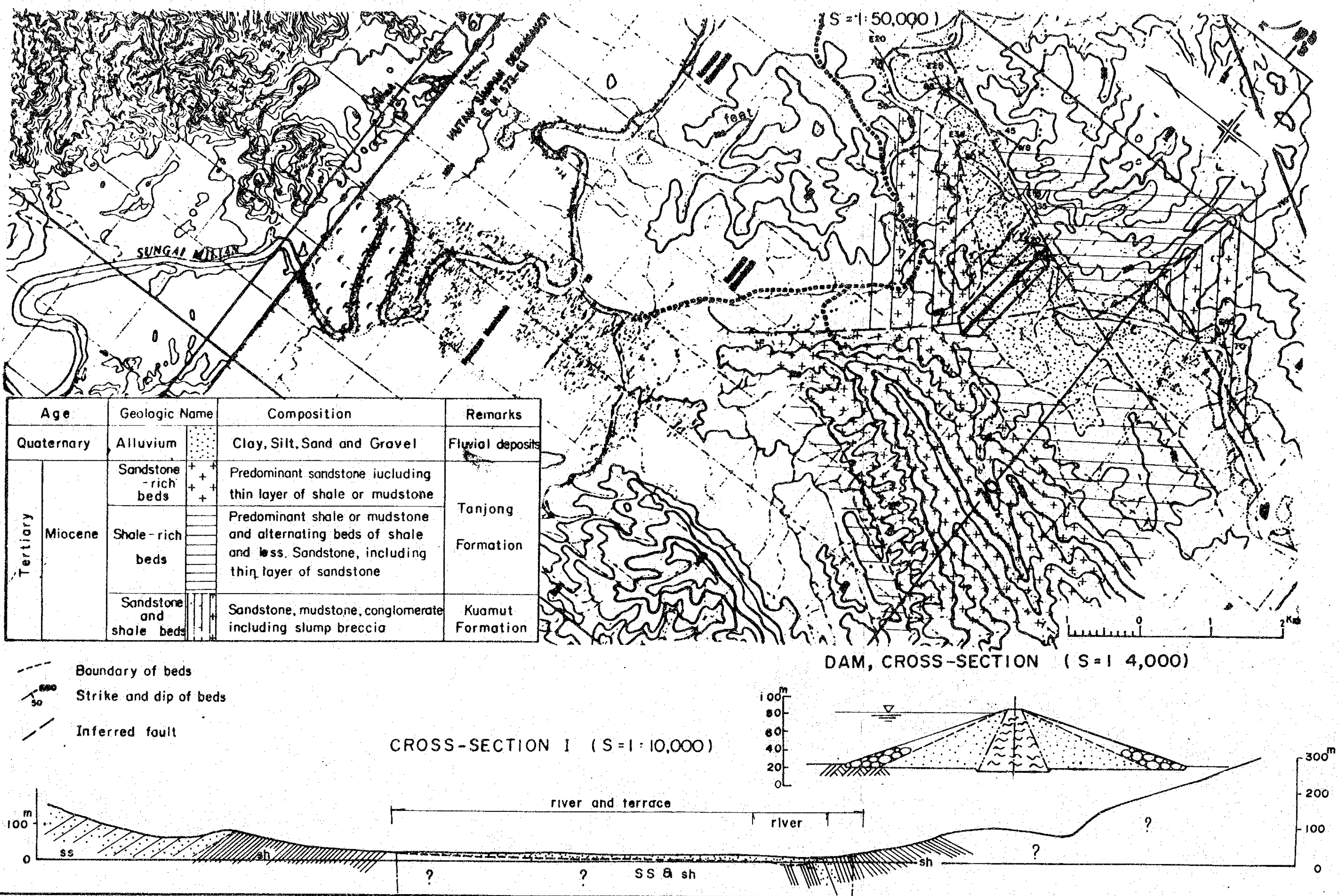


Fig.II-4 GEOLOGIC MAP OF THE PROPOSED MILIAN DAMSITE

Fig. II-5 GEOLOGIC MAP OF THE PROPOSED KUAMUT DAMSITE



Age		Geologic Name	Composition	Remarks
Quaternary		Alluvium	Clay, Silt, Sand and Gravel	Fluvial deposits
Tertiary	Miocene	Sandstone-rich beds	Predominant sandstone iucluding thin layer of shale or mudstone	Tanjong Formation
		Shale-rich beds	Predominant shale or mudstone and alternating beds of shale and less. Sandstone, including thin layer of sandstone	
		Sandstone and shale beds	Sandstone, mudstone, conglomerate including slump breccia	Kuamut Formation

Fig. II-6 RESULTS OF TEST BORINGS

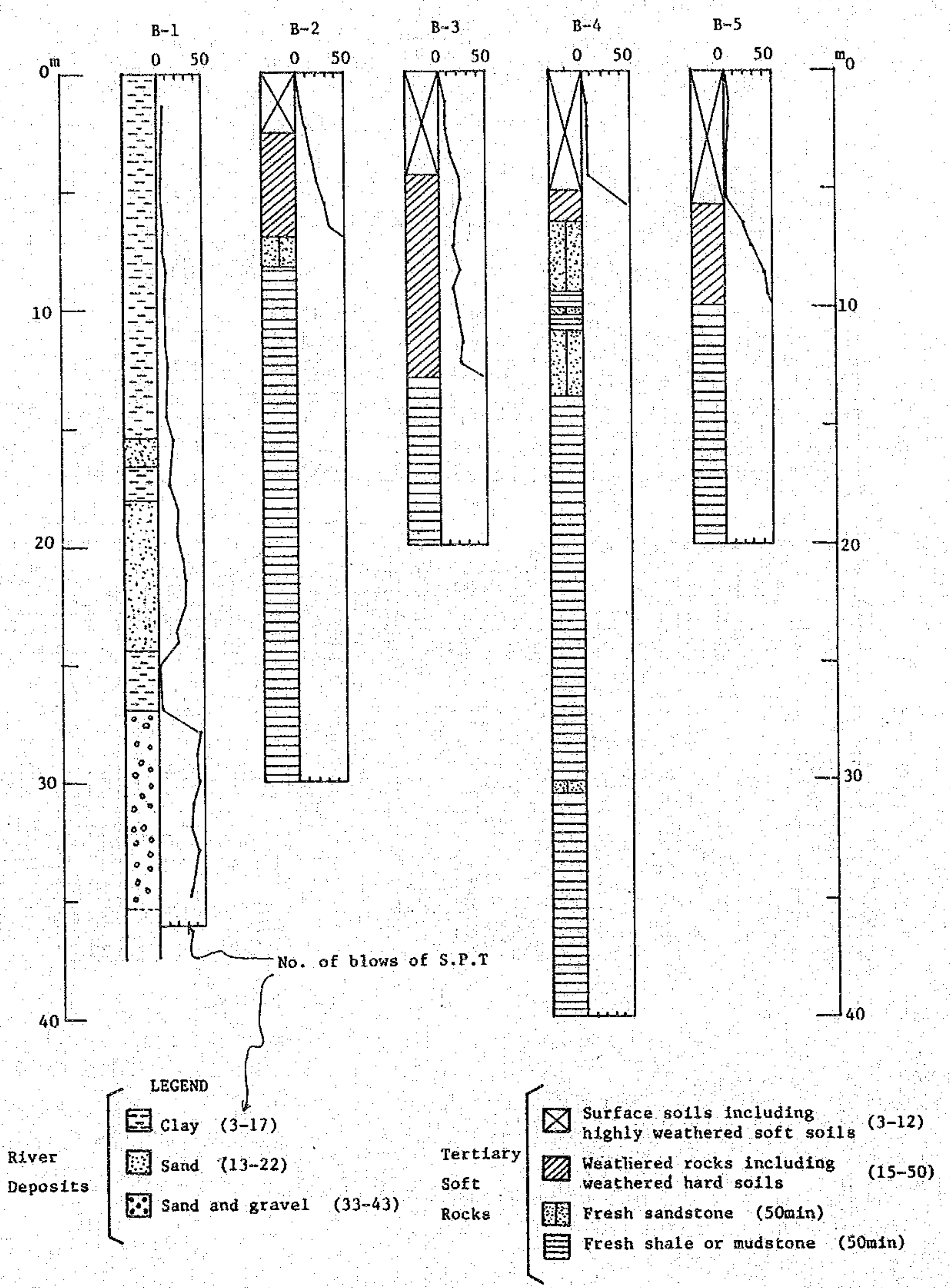
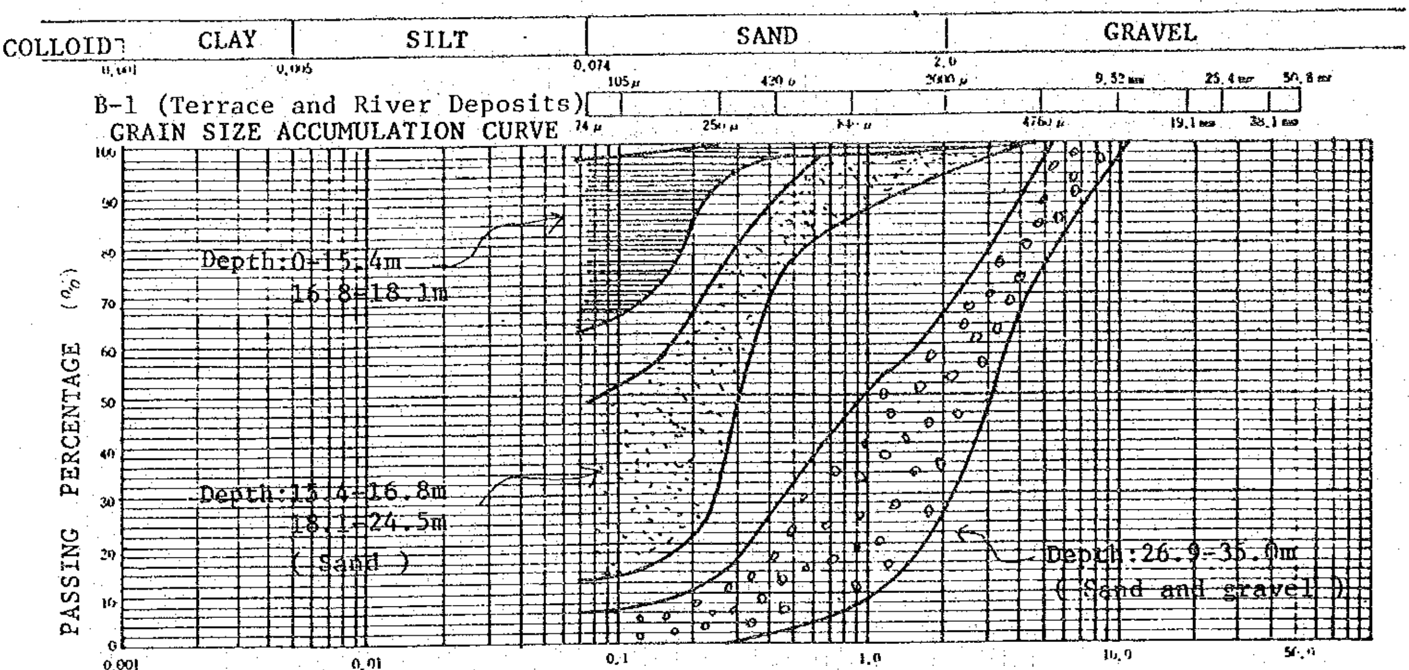
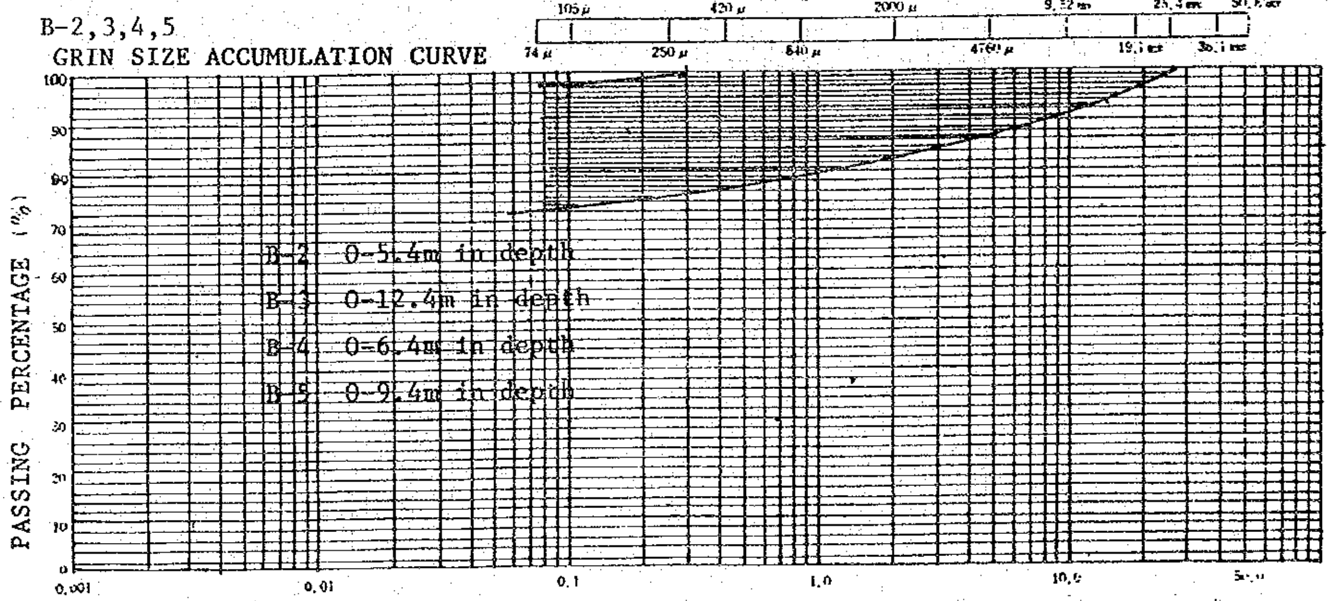


Fig. II-7 THE RESULT OF GRAIN SIZE ANALYSIS





III. DAM

III. CONTENTS OF DAM

LIST OF TABLES

LIST OF FIGURES

1. GENERAL

It has been concluded that the construction of a dam is the most economical measure for the purpose of flood control, agricultural and hydro power development in the Kinabatangan River Basin.

In this sector, Balat has been selected as the optimum damsite in the entire project area, and then the proposed scale, preliminary design, construction schedule and cost estimate of the proposed Balat dam have been studied.

In the present pre-feasibility study, the construction planning of the proposed dam has been performed based on the topographical and geological data so far available.

2. SELECTION OF OPTIMUM DAMSITE

This section deals with the selection of the optimum damsite taking such steps as mentioned below.

1) In the entire basin, a selection of possible damsites is first made from the viewpoint of topographic features.

2) Out of the possible damsites mentioned above, the nominated damsites are selected through the rough study on economical advantage.

3) The optimum damsite is selected from the nominated damsites taking technical feasibility, economical advantage and social impact into account.

2.1 NOMINATED DAMSITES

2.1.1 Location of Possible Damsites

Possible damsites located in the Kinabatangan River Basin have been selected from the study of the topographic maps, scale 1:50,000, and aerial photographs. The location of the possible damsites is shown in Fig. III-1. The total number of possible damsites is 13, consisting of 3 on the main stream and 10 on the tributaries in the upstream basin of the Kinabatangan River. General criteria used for the selection of the possible damsites are as follows:

- Damsites are located at gorges
- A large storage capacity is assured.

2.1.2 Selection of Nominated Damsites

The comparative study of the foregoing 13 possible damsites is shown in Table III-1.

From the 13 possible damsites, nominated damsites are selected based on the criteria presented below.

1) High economicality : Ratio of effective storage capacity per dam body volume is high

2) High flood control efficiency : The catchment area governed by the dam and reservoir is larger.

Judging from the conditions No. 1) above, Pinangah, Milian, Deramakot and Balat damsites show their advantage over the others. However, Pinangah fails to satisfy the condition No. 2) because it is located in the upstream basin. As Milian dam is solely for the control of the Milian River, another dam needs to be constructed for flood control of the Kuamut River. Both Milian and Kuamut dams are then necessary as a complementary pair for the full flood control over the project area.

From the above, Balat, Deramakot and Milian-Kuamut are selected as appropriate for the nominated damsites. A further detailed study on the three nominated damsites will be made in the following section.

2.1.3 Topography and Geology of the Nominated Damsites

The topographic and geologic conditions of the nominated damsites, namely, Balat, Deramakot and Milian-Kuamut, are the points of argument here.

The location of the nominated damsites is shown in Fig. III-2. The geological maps of each damsites will be shown in "Geology" sector.

Balat Damsite

1) Topography

The damsite is situated upstream just near Kampung Balat which is about 260 km upstream from the estuary.

On the left side of the river at the damsite is a hill with a relatively steep slope. Conversely, very gentle slope can be observed on the right side. Four small valleys can be seen on the right side also.

2) Geology

Bedrocks such as sandstone and mudstone are found at the both sides of the river, all of which were formed in the geological age of Oligocene to Miocene in the Tertiary. And Alluvium in the Quarternary, which is composed of very thick sediments, covers these bedrocks along the present river and other valleys.

The stratigraphic cross-section of the Alluvium reveals, in descending order, layers of silty clay, sand, and gravel.

Deramakot Damsite

1) Topography

This is located at about 10 km upstream of the aforementioned Balat damsite, and its catchment area is approximately 10,360 km^2. Topographic conditions is about the same as Balat damsite, except that the right side of the nominated dam has very gentle slopes with some valleys but without any apparent mountains.

Construction of one dam, which has approximately 1.3 km width of river including terrace plain, may be considered at this location; a few sub dams on right side might be necessary to be built.

2) Geology

Geologic conditions including its structure around the nominated damsite is about the same as Balat damsite, except shale-rich beds have prominent distribution around the damsite and the trend of some inferred faults show northeast direction.

Milian-Kuamut Damsite

1) Topography

- Milian Damsite

It is situated about 30 km upstream along the Miliam river from the confluence of the Milian and the Kuamut rivers, which are tributaries of the Kinabatangan River. The total distance from the estuary to the Milian damsite is about 330 km. Its catchment area is approximately 6,650 km^2.

A wide flat is extending on both sides until it reaches a nominated dam abutment a few kilometers away on the right side. On the left side two small hills stand within a short distance from each other.

Two sub dams will be required on the left side and one sub dam on the right to stem a tributary which joins the Milian River at the downstream of the nominated dam. This damsite assumes a V-shape.

- Kuamut Damsite

This is situated about 15 km upstream of the Kuamut River from its confluence with the Milian River. Its catchment area is approximately 3,100 km^2.

Rock is being exposed immediately on the right side with no problem for securing a dam abutment. On the left side, a gentle slope extends until it reaches a clearly mountainous terrain a few kilometers away.

2) Geology

- Milian Damsite

Bedrocks around the nominated Milian damsite, consist of sandstone-rich beds and shale-rich beds of Tanjong and Kulapis Formation. General properties of these rocks such as weathered depth and engineering geologic condition are not so different from those of Balat Damsite.

- Kuamut Damsite

Bedrocks of the nominated Kuamut damsite consist of sandstone-rich beds, shale-rich beds and sandstone and shale beds of Tanjong and Kuamut Formations. General properties of those rocks are considered not to be so different from Balat damsite, but bedrocks are somehow sheared more than those at the other damsites, because of the existence of Kuamut fault.

2.2 OPTIMUM DAMSITE

From among the three nominated damsites, Balat has been selected as the optimum damsite of the project on the basis of the following study from the economical point.

For the selection of the optimum damsite, the study of economical comparison among the three nominated damsites, i.e., Balat, Deramakot and Milian-Kuamut, has been done. The economic justification is based on B/C ratio (the ratio of the benefit to cost).

In this comparative study, the cost and benefit will be estimated on the following premises.

Cost

The total cost for economic justification of the optimum damsite is the sum of construction cost of the dam and agricultural development cost. The construction cost of each dam will be estimated based on a proportion of dam body volume. The agricultural development cost is estimated in terms of paddy cultivation in the downstream of the project area, which will be relieved of annual floods by the implementation of dam construction.

The cost-items such as hydro power development, settlement, operation and maintenance costs are not taken into consideration for the comparative study because of their lesser bearings on the damsite selection.

Benefit

The increased agricultural production under the terms of non-flood damages is taken up as expected benefit in this study.

The benefit arising from protection of infrastructures against floods is disregarded on the ground that the expected benefit shares only a small portion of the total benefit. And hydro power generation benefit is also excluded as it is almost the same among the three nominated damsites.

The result of the benefit and cost comparisons shows ratios of 0.08, 0.07 and 0.04 at Balat, Deramakot and Milian-Kuamut, respectively as shown in Table III-2. These figures show that the location of Balat is better fitted by far above the others.

From the geological viewpoint, the selected Balat damsite is also recommended as the optimum damsite compared to the others (refer to "Geology" Sector).

3. PROPOSED SCALE OF BALAT DAM AND RESERVOIR

3.1 CIRCUMSCRIPTION OF THE DEVELOPMENT SCALE OF BALAT DAM AND RESERVOIR

The development scale of the proposed Balat dam is circumscribed from topographical, geological and social conditions as mentioned below.

Topographical Condition

The longitudinal section of the dam suggests that as soon as its crest exceeds EL.60 m or so, an abrupt increase in dam body volume will be required.

Geological Condition

Geological survey performed at the main damsite reveals that the foundation of the dam consists of very thick Alluvium deposit. From the viewpoint of geology, construction of a very high dam does not seem feasible.

Social Aspect

Though data so far available are not sufficient enough to allow proper evaluation, in the case a reservoir stage exceeds high water level of around EL.50 m, the number of submergible houses will be increasing, which is tremendous impact on the welfare of the inhabitants now living in the submerged area. Distribution of the submergible Kampung and number of houses in submerged area are shown in Figs. III-3 and III-4.

3.2 PROPOSED SCALE OF BALAT DAM AND RESERVOIR

The proposed scale of the dam and reservoir has been determined as the scale which can fulfill the required storage capacities mentioned below for the development of the project area.

Storage Capacity Required for Flood Control

The storage capacity of 4.665×10^9 m^3 will be allocated for regulating a 20-year probable flood of 5,400 m^3/s, which is the standard project flood, down to 900 m^3/s at the damsite (refer to "Hydrology" sector).

Storage Capacity Required for Irrigation

The storage capacity of 0.120×10^9 m^3 will be allocated for water resources of the irrigation water supply (refer to "Agriculture and Irrigation" sector).

Storage Capacity for Hydro Power

Particular storage capacity for hydro power is not allocated in the reservoir storage capacity because the generating type is a run-of-river type (refer to "Hydro Power" sector).

Sediment

The sediment storage capacity will be estimated on the basis of specific sediment, 200 m^3/km^2/year. This figure with ample safety margine in design criteria has been arrived at from both the recorded data on sediment load in this river and the projected value of the Padas River Reservoir on the west coast (refer to "Hydrology" sector).

The required storage capacity of the Balat reservoir are as follows:

Gross storage capacity	:	5.0×10^9 m^3
Flood control capacity	:	4.665×10^9 m^3
Irrigatin capacity	:	0.120×10^9 m^3
Effective storage capacity	:	4.785×10^9 m^3
Sediment capacity	:	0.215×10^9 m^3
Submerged area	:	520 km^2

The submerged area is shown in Fig. III-5.

Water stages of the reservoir which correspond to the storage capacities above are as follows:

Design flood water level (D.F.W.L.)	:	EL.43.0 m
Surcharge water level (S.W.L.)	:	EL.37.0 m
Normal water level (N.W.L.)	:	EL.17.5 m
Low water level (L.W.L.)	:	EL.16.5 m

The allocation of the storage capacity is shown in Fig. III-6. The relation curve between elevation and storage capacity is illustrated in Fig. III-7.

The above scale of Balat dam meets the condition of topography, geology and society mentioned in the foregoing section 3.1.

4. PRELIMINARY DESIGN

Based on the proposed scale of the dam and reservoir which has been studied in the foregoing section, the preliminary design has been done.

4.1 DAM

The Balat dam comprises a main dam and four sub dams. The main dam which is located on the Kinabatangan River will be built to shut down the river water and the sub dams which are situated on the right side of the main dam to close saddles for storing the reservoir water.

The followings are the principal features of each dam which is decided on the basis of the study results which will be mentioned in the parts, 4.1.1, 4.1.2, 4.1.3 and the section, 4.2 Spillway.

	Main dam	Sub dam			
		No. 1	No. 2	No.3	No. 4
Height (m)	46	16	42	10	26
Length (m)	530	540	550	120	780
Dam volume (m^3)	2,150,000	330,000	1,830,000	20,000	990,000

The aggregate total volume of these dams will be 5,320,000 m^3.

General plan, profile and cross-section of the dam and appurtenant structures are illustrated in Figs. III-8, III-9 and III-10, respectively.

4.1.1 Dam Type

As for dam type, an earthfill dam, zone typed, with a riprap slope was selected for the following reasons: -

1) Bedrocks around the damsite consist of sandstone bed and mudstone bed. Alluvium in Quarternary which is composed of very thick sediment, covers these bed rocks. The mudstone and Alluvial sediment cannot withstand a concrete dam.

2) Construction materials for an earthfill dam are availble around the damsite, but it is difficult to obtain rock materials around this area.

4.1.2 Freeboard of Dam

The freeboard of 3.0 m provided above the Design Flood Water Level of 43.0 m is adopted for safety of dam body in due consideration of raising reservoir water level caused by the following factors.

- Wind velocity : 30 m/sec.
- Maximum distance of waving in reservoir : 7 km
- Upstream side slope of dam : 1:3.0
- Gate : None
- Freeboard specifically provided for a fill dam : 1.0 m

4.1.3 Dam Foundation Treatment

The geological investigation done during the present pre-feasibility study which includes 5 boring tests, two boring tests for main damsite and three for sub damsites, briefly revealed geological particulars of the Balat damsite.

According to this study, it is disclosed that the foundation of the main damsite consists of Alluvial deposit of more than 36 m deep and is composed of silty clay, sand and gravel layers. It is also found that the bedrocks at the four sub damsites are covered by a few meters thin weathered soil layer.

Based on the geological investigation for the damsite mentioned above, the treatment of dam foundation has been studied.

As for the treatment of the sub dam foundation, the weathered surface soil covering the bedrocks will be removed. On the other hand, for the treatment of the main dam foundation which comprises thick Alluvial deposit, three measures such as cut-off trench, continuous cut-off wall and impermeable blanket have been taken up and the comparative study on these measures has been made from the economical and technical points. The comparison of the three measures is shown in Fig. III-11.

Judging from this figure, the impermeable blanket measure which is most economical and easier in construction execution, is adopted as the optimum measure against the poor main dam foundation.

Treatment of dam foundation is very important for dam construction. Consequently, the detailed investigation will be required during the further stage.

4.2 SPILLWAY

4.2.1 Design Flood Discharge

For the design flood discharge for the spillway of Balat dam, 15,500 m^3/s which is the biggest value among the following three cases is adopted. The more details will be referred to "Hydrology" sector.

1) Past maximum flood discharge ......5,400 m^3/s
2) Flood discharge of 200-year probability (1.2 times bigger in case of an earthfill dam) .....10,200 m^3/s
3) Regional specific discharge and Creager's Curve (C=45) ....15,500 m^3/s

4.2.2 Type of Spillway

For the spillway, two types are considered; one is a gate type and the other is a free overflow type without gate. Here, the free overflow type is adopted to discharge the flood from the viewpoint of avoiding the man-made flood and of easier maintenance of the facility.

4.2.3 Size and Location

To determine the size of the spillway, a comparison was made on construction costs of spillway and dam body in 5 different widths, i.e. 500, 600, 700, 800 and 900 m (refer to Fig. III-12). Based on the findings of the foregoing comparison, the overflow width of 600 m was adopted as economically most advantageous. The depth corresponding to the width mentioned above is 6 m.

Taking the topographic configuration of the damsite, one spillway is located on the right side of the main dam, and the other between No. 1 and No. 2 sub dams, each 300 m in width, to comply with the required total of 600 m as specified in the design. The profile and cross-section of the spillway are shown in Fig. III-13.

4.3 OUTLET FACILITY

The two outlet facilities are to be constructed, one is to control the flood discharge and the other to maintain the reservoir water stage at Normal Water Level (N.W.L.). Both are located in parallel on the left side of the main dam where the bedrock is sound. The plan of the outlet facility is shown in Fig. III-14.

Outlet Facility for Flood Control

The outlet facility for flood control is designed so that a 20-year probable flood of 5,400 m^3/s, which is the standard project flood at the Balat damsite, can be regulated down to 900 m^3/s. The facility is built with concrete and the size of overflow section is 5.0 m in width and 28.5 m in depth.

Outlet Facility for Maintaining N.W.L.

This outlet facility is given a design discharge of 450 m^3/s to maintain the reservoir water stage at N.W.L. normally. It consists of three outlet pipes (7 m in diameter each) and each has an emergency gate and main gate. This facility is also to be utilized for power generation.

4.4 DIVERSION WORKS

The diversion works are required for construction of main dam and No. 2 sub dam and no diversion works for construction of other three sub dams which are located in higher elevated area.

The diversion works consist of temporary diversion tunnel and coffer dam. All the coffer dams are built with earth. Two different discharges for diversion work design are adopted because of different construction period between of main dam and of No. 2 sub dam.

4.4.1 Diversion Works for Main Dam

The design diversion discharge of the main dam is fixed at 5,400 m^3/s which is the equivalent of a 20-year probable flood.

The discharge is diverted by two temporary diversion tunnels (8 m in diameter and 950 m in length each), and by Lantangan river, a tributary of the Kinabatangan River, joining from the right. Under these circumstances, water level of the upstream side of the river would likely to come up to 20.7 m, so the crest elevation of the upstream coffer dam was fixed at EL.22.0 m. On the other hand, the crest elevation of the down stream side coffer dam was fixed at 20.0 m because the water level of the downstream side of the river would come up to EL. 19.5 m.

4.4.2 Diversion Works for Sub Dam No. 2

The design diversion discharge of the sub dam No. 2 was fixed at 3,500 m^3/s which is the equivalent of a 5 year probable flood.

The above-mentioned discharge is transported to the downstream through the temporary diversion tunnels and the outlet facility of the main dam. Under the circumstances, water level of the upstream coffer dam would likely to come up to EL. 26.0 m, so the crest elevation of the coffer dam was fixed at 27.0 m. The crest elevation of the downstream coffer dam is fixed at 18.0 m because the water level of the downstream side of the river would come up to EL. 17.5 m.

4.5 ACCESS ROAD

The access road for transportation of construction materials and equipment is to link the damsite to the main road running between Sandakan and Kota Kinabalu. The access road is about 48 km in length and may require two bridges.

The metaled access road of 10 m wide is to be constructed after excavating the surface soil of 2-3 m deep.

The route of access road is illustrated in Fig. III-15.

5. CONSTRUCTION SCHEDULE AND COST ESTIMATE

In working out this construction plan, careful consideration of and evaluation with such items as the availability of construction machinery and material in the local, their prices, the facilities and capability for repairing of the machinery and equipment to be mobilized for construction works, the conveniences of their transport to the job sites, and other necessary items relevant to construction work has been made.

Construction schedules proposed in this report are those which have been worked out essentially from the technical viewpoints and, therefore, it is necessary to review them from the standpoint of actual implemention and to make some amendment or alternation.

5.1 CONSTRUCTION SCHEDULE

Construction works of Balat dam will follow the stages as mentioned below:

- Diversion work : Oct. 1985 - Mar. 1987
- Coffer dam : Apr. 1987 - Sep. 1988
- Outlet facilities: Jan. 1987 - Jun. 1990
- Main dam : Oct. 1988 - Dec. 1990
- Sub dam : Jan. 1990 - Jun. 1992
- Spillway : Jan. 1988 - Jun. 1992

As entire construction period covering all stages above will be 10 years and is shown in Fig. III-16.

5.1.1 Workable Days

Earthfill dam construction work largely consists of the earthwork which is bulky in volume. The workable days of a year for dam construction depend on climatological condition, particularly rainfall, at the damsite.

Under the circumstance above, embankment and concrete works will be done except rainy days (above 20 mm daily rainfall), holidays and days for periodical inspection, while excavation work will be continuously done all through the year except holidays and days for periodical inspection.

The workable days by kinds of work mentioned above have thus been estimated as follows.

Excavation : 290 days/year or
24 days/month

Embankment, concrete work: 240 days/year or
20 days/month

5.1.2 Construction Materials

Lumbers, bricks, stones, fuels and oils which are necessary as the construction materials in general are almost entirely obtainable locally, but the structural steel, iron/steelpipes, water gates, valves and other materials which need to be of high precision and good quality will have to be imported. Cement is partly imported and partly purchased locally.

5.1.3 Construction Machinery

The construction works covered under dam construction call for deployment of various kinds of construction machinery which are mostly to be imported except a few items being manufactured in Malaysia. Due to limitations and problems as for their performance, replacement of parts, and durable period, etc., it is difficult to expect transfer of the construction machinery which has been or are used elsewhere to this project which is comprised of dam requiring a considerable long period of time for their construction.

Under such circumstances, the construction machinery required for dam construction will have to be imported anew in their majority.

5.2 COST ESTIMATE

5.2.1 Construction Cost

Total construction cost of Balat dam comprises main works, land acquisition, engineering cost and plus 10% physical contingencies.

The total cost will be US$201 million, out of which US$97 million is in foreign currency and US$104 million in local currency.

The construction cost by kinds of works is shown in Table III-3.

5.2.2 Operation, Maintenance and Replacement Cost

The dam operation and maintenance cost will comprise the personnel cost, operational machinery and equipment, vehicles, boats, administrative cost and miscellaneous. As an annual operation and maintenance cost for the period from the completion of dam construction to the end of the project life, US$0.15 million is estimated. Replacement cost of the gates after 35 years from the initial dam operation is US$7.4 million.